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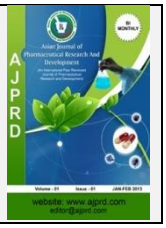

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Review Article

A Review of a Hair-Care Formulation for Hair Health

Monali G. Chaudhari [1*], Tejaswini G Malge, Darshana Shirbhate, Vrushali Potdar

Department of pharmaceutics, P.R Patil Institute of Pharmacy, Talegaon (S.P) - 442204, India

A B S T R A C T

Hair plays a vital role in appearance, personality, and overall well-being, making its care an important aspect of cosmetic science. Hair is primarily composed of keratin and undergoes a natural growth cycle that can be influenced by genetic, physiological, and environmental factors. Damage to hair fibers occurs due to excessive use of chemical treatments, synthetic dyes, and environmental stress, which necessitates the development of effective and safer hair-care formulations. This review highlights the structure and physiology of hair, common causes of damage, and the role of cosmetic preparations such as shampoos, conditioners, oils, gels, and dyes in maintaining hair health. Particular emphasis is placed on herbal ingredients such as Amla, Shikakai, Henna, Hibiscus, and flaxseed, which demonstrate natural conditioning, coloring, antifungal, and strengthening properties. Modern advancements including silicone-based ingredients and optimized formulations provide improved manageability, shine, and protection against heat and chemical damage. Evaluation parameters such as foam stability, detergency, conditioning effect, viscosity, microbiological safety, and irritation studies are essential for assessing product performance. Overall, integration of natural extracts with modern cosmetic science offers a promising approach to achieving safe, effective, and consumer-friendly hair-care formulations.

Keywords: Hair care, Shampoo, Conditioner, Herbal extracts, Hair gel, Hair dye, Coconut oil, Argan oil, Silicones, Flaxseed, Hair health

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*Address for Correspondence:

Monali G. Chaudhari, Department of pharmaceutics, P.R Patil Institute of Pharmacy, Talegaon (S.P) - 442204, India

INTRODUCTION:

Hair is simple in structure made of the root and shaft. The root is enclosed in the hair follicle, submerges into the skin in inclination and ends down to the bulb; while hair shaft is the part of the hair seen above the skin. Hair is made up of tough protein called keratin that decides the strength of hair. Hair structure is made up of different layers and structures. Usually hair consists of two parts: (a) Follicle; (b) Shaft. The hair follicle is the centre of the biological activity like hair growth, pigmentationwhereas the hair shaft is considered to be dead and is mainly made of protein. The hair follicle is the point from which the hair grows. It is a club-shaped structure in the skin. At the end of the follicle is a network of blood vessels that supply nutrients to feed the hair and help it grow. This is called the papilla. Surrounding the papilla is a bulb. The hair bulb forms the base of the hair follicle. In the hair bulb living cells divide and grow to build the hair shaft. Blood vessels nourish the cells in the hair bulb and deliver hormones that modify hair growth and structure at different times of life. Adjacent to the hair follicles are glands. The most important one of these glands is the sebaceous gland, which secretes oil that helps to keep the hair conditioned, is associated with the bulb. The hair bulb has special cells known as melanocytes which produce the pigment called melanin. This melanin gives hair its colour. Within the skin, internal and external root sheaths cover the hair follicles. The outer rooting of a hair follicle has a continuous growth cycle along with the epidermis.

The part of the hair seen above the skin is called the hair shaft. The hair shaft is made up of dead cells that turn into protein called keratin and binding material, together with small amounts of water. Keratin makes hair both strong and flexible. Like all proteins, keratin is made up of a chain of amino acids that forms a helical, or spiral, shape. These helices are connected by strong bonds between amino acids. These bonds make hair strong.

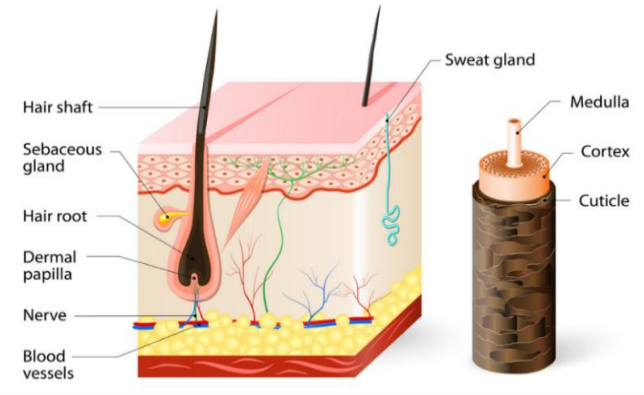

Figure 1: Structure of Hair

The hair shaft form a 3 layer: 1) The medulla, 2)The cortex, 3)Thecuticle (1)

Historical Perspective:

The hair is a body structure readily accessible for scientific observation, yet much remains to be understood regarding its growth and regulation. The first dermatologist to encourage study of the hair was Unna of Ham burg in 1876.(2)One of Unna's students, Engman, became interested in the embryology and development of the hair follicle. His work was furthered by Danforth, Trotter, and Cady, who published the foundation work on hair formation in 1925.(3)Further works on the development of the hair follicle continued with Pinkus (1958),(4)Sengel (1976),(5) and Spearman (1977).(6)

Hair Growth Cycle:

Hair growth continue on a cyclical basis with each hair growing to genetically determinedmined and age-determined length, remaining in the follicle for a short period without growth, and eventually shedding followed by regrowthThe growth phase, known as anagen, lasts approximately 1000 days, and the transitional phase, or catagen, lasts about 2 weeks. The resting phase, or telogen, lasts: approximately 100 days. Scalp hair is charecterized by a relatively long anagen and at relatively short telogen with the ratio of anagen to telogen hairs of 90:10." Only 1% or less of the follicles are in catagen at any given time. The healthy individual loses 100 hairs per day. It is estimated that each follicle completes this cycle 10 to 20 times over a lifetime, but the activity of each follicle is independent. The mechanism signaling the progression from one phase to the next is unknown, but the duration of anagen determines the maxi mum length to which the hair can be grown. Hair growth can be affected by physical factors (e.g., severe illness, surgery, weight change, pregnancy, hormonal alterations, thy roid anomalies, dermatologic disease) and emotional factor but is unaffected by physical alterations limited to the hair shaft (e.g., shaving, curling, combing, dyeing). Plucking of the hairs from resting follicles can stimulategrowth (7).

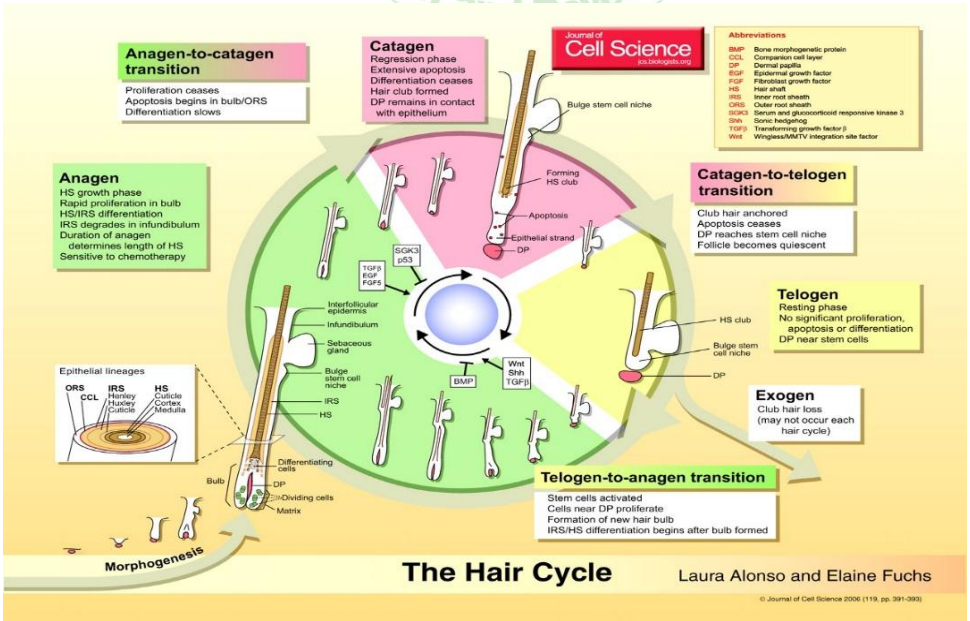

Figure 2: The Hair Cycle

Hair Damage:

The hydrophobicity of the hair is possible thanks to the 18-MEA lipid layer. Removal of this covalently linked fatty acid renders the fiber hydrophilic. When wet, virgin hair can be stretched by 30% of their original length without damage; however, irreversible changes occur when hair is stretched between 30% and 70%. Stretching to 80% causes fracture. Hair is porous and damaged hair is intensely so. Water absorption causes the hair shaft swelling Excessive or repeated chemical treatment, grooming habits, and environmental exposure produce changes in hair texture and if extreme can result in hair breakage. These changes can be seen microscopically as "weathering" of the hair shaft and contribute to tangling, and frizzing Weathering is the progressive degeneration from the root to the tip of the hair. Normal weathering is due to daily grooming practices. When the hair is extremely weathered and chemically treated, there may be scaling of the cuticle layers, removal of the 18-MEA and cuticle crack. If the cuticle is removed, the exposure of the cortex and further cortex damage may lead to hair fiber fracture. The use of hair cosmetics may restore hair cuticle damage and prevent hair breakage by reducing friction and water pick up. (8-12)

Hair Care:

If, on one hand, hair texture and shine are usually related to hair surface properties, on the other hand, the integrity of hair is due to the hair cortex. For this purpose, hair products that improve the structural integrity of hair fibers and increase tensile strength are available, along with products that increase hair volume, reduce frizz, improve hair manageability,and stimulate new hair growth interestingly ,modern cosmetic product are formulate to clean hair from detritus,and to restore and improve hair physiology .for example,intensive conditioning agent can temporarily replace the f-layer ,improving moisture retention in the cortex and rebuilding some of the reduced physical properties of hair.therefore,The boost in hair shine is a key benefit of modern product.(13)

Shampoo

Definition: A shampoo is a preparation of a surfactant (i.e.surfaceactivematerial) in a suitable form liquid, solid or powder which when used under the specified conditions will remove surface grease, dirt, and skin debris from the hair shaft and scalp without adversely affecting the user.(14)

Shampoo in simple terms is a hair care product designed to clean the scalp skint along with its hairs Incidentally, the term shampoo entered the English language through India where the Hindi word "champoo" was used meaning to press or massage; it was used to denote cleaning through massage of the hair and skin(15)Cleaning the hair has always been a tough task especially for women. An average western woman has 4-8 square meters of hair(16)This will probably be more for the average Indian women due to culture of keeping long hair. Traditional soaps which were used earlier for both skin and scalp are not recommended anymore for hair cleaning as they don't have good lathering capability and leave behind "soap scum" when mixed with hard water which is difficult to rinse off. Modern shampoo as it is known today was first introduced in the 1930s with Drene, the first shampoo using synthetic surfactants instead of soap. Used initially for laundry and for cleaning carpets and cars, they later evolved as hair shampoo.(17)

Figure: 3 Marketed product of shampoo

Ideal properties of shampoo:

- It should effectively and completely remove dust or soil, excessive sebum or other fatty substances and loose corneal cells from the hair.
- It should produce a good amount of foam to satisfy the psychological requirement of the user.
- It should be easily removed on rinsing with water.
- It should leave the hair non-dry, soft, lustrous with good manageability.
- It should impart a pleasant fragnance to the hair.
- It should not cause any side-effects and irritation to skin or eye.
- It should not make the hand rough and chapped.(18,19)

Requirements of a shampoo

- To remove sebum (the secretion of the sebaceous glands) and atmospheric pollutants from the hair and scalp.
- To remove the residues of previously applied hair treatments, e.g. polymeric constituents from styling lotions and hair sprays
- To deliver an optimum level of foam to satisfy theexpectation of the user.
- To leave the hair in a satisfactory condition after rinsing so that it can be combed easily both in the wet and drystate.

- To perform as a vehicle for the deposition of beneficialmaterials onto the hair and scalp.
- To be non-toxic and non-irritating to the hair and the scalp.
- To be non-damaging to the tissues of the eye if inadvertently splashed.(20)

Types of shampoo:

Shampoos are of the following types:

- Powder Shampoo
- Liquid Shampoo
- Lotion Shampoo
- Cream Shampoo
- Jelly Shampoo
- Aerosol Shampoo
- Specialized Shampoo
- Conditioning Shampoo
- Anti-dandruff Shampoo
- Baby Shampoo.

Raw Materials Required For Preparation ofShampoo

Surfactant

surfactants are used to enhance the foaming property ofshampoos. Four different types of surfactants are available inthemarket.(21)

Cationic surfactants

Cationic detergents produce foam well and have reasonable cleansing power. They also leave hair luster and freed from. electrosing charge. It would, therefore, appear that cationic detergentare ideal for shampoo.but thank to its tendency to corneal eye tissues, they are not used frequently in shampoos. Examples are quaternary ammonium salts. amines with amide linkages.

Non-ionic surfactants

Non-ionic detergent have sufficient cleansing power but onlya couple of have sufficient foaming properties. Therefore, these aren't used as principal foaming agents. However, these haveremarkable foam booster and stabilizing properties and intrinsically, are used as foam stabilizerthese are mild and non-irritating to the skin. Some newly developed non-Ionics possess good foaming power and may be used as principal foaming agents. Examples are carboxylic esters, glycol ester of carboxylic esters, glycol ester,carboxylic acid,anhydrosorbitol esters.

Anionic surfactants

Anionic surfactants include a number of class of compounds. out of which important ones are mentioned here in context with hair preparations. Examples are carboxylatessulphonates, alkyl sulphates.

Amphoteric surfactants

Amphoteric surfactants are known for their mildness and areused in mild shampoos. These are compatible with widerange of surfactants. Examples are N-alkyl amino acids,betaine, alkyl imidazolines, N-coco 3-aminopropionic acid.

Viscosity modifier

These agents improve the viscosity of formulation. Examplesare electrolytes likes ammonium chloride and Sodium chloride, Natural gum likes gum karaya and gum tragacanth, cellulosederivatives like Hydroxyethyl cellulose, hydroxypropyl cellulose, carboxymethyl cellulose. Others are TEA soaps, alkanolamines, phosphate esters, amidoamine Oxides.

Opacifying and clarifying agent:

A number of materials can be used for opacifying or giving pearlescent effect. May improve by solubilizing alcohols, phosphates or non-ionic solubilizers. Examples are Propylene glycol, glycerol monostearate, palmitates ethanol,Isopropanol esters.

Conditioning agents.

These agents are intended to improve manageability, feel &luster of the hair. The materials which have been claimed tohave conditioning effect on hair. Examples are lanolin, mineral oil, and natural products like polypeptides, herbalextracts, resins, quaternary compound, silicon and lecithin.

Sequestering agents

It used to prevent deposition of calcium and magnesium saltsof soaps on to the hair. Examples are EDTA salts, polyphosphates, citric acid.

Perfumes

There are two important aspects which should be ascertained before final selection of fragrance for shampoos. Fragrance must be soluble in shampoo and it should be compatible with it. Examples are herbal, fruity or floral fragrances can be used in shampoo.

Preservatives

Surfactant in shampoos tends to interfere with bactericidal activity of antibacterial in order that high concentrations of preservatives are necessary in shampoos. Many manmade products are susceptible to microbial attack, if not preserved efficiently. Bacterial growth in shampoos can cause breakdown of detergents in shampooPara hydroxy leading to discoloration of the merchandise. One important fact to be kept in mind while selecting preservatives for shampoos is that surface in shampoo tend to interfere with bactericidal activity of antibacterial therefore higher concentration of preservatives are necessary in shampoos. Examples are carboxylic acid. alcohol, formaldehyde, benzoate of soda, butyl paraben(22)

General method is used for the preparation of Shampoo:

- The detergent is converted into a solution form, or a detergent solution may how directly be obtained from the manufacturer.
- Take about half of the container solution in a separate container to it, add the secondary surfactant i.e, alkanolamine. And dissolve it with stirring.
- To the remaining half of the detergent solution add perfuming agent and dissolve it. And add it to the alkanolamine solution.

- Colour and antiseptics will dissolve separately in a sufficient amount of water and Added to the main solution.
- Final volume of the preparation is usually adjusted by the addition of clear sterile water.
- However, When the preparation contains lauryl alcohol ether sulphate. It is necessary to adjust the viscosity of the shampoo.
- Viscosity adjustment is done by using an Elec chloride solution. Usually, Sodium chloride solution is added continuously.(23)

Example of shampoo formulations:

Clear liquid shampoo

Table 1: Formulation of clear liquid shampoo

Ingredients	Quantity
Triethanolamine lauryl sulphate	50 g
Lauricisopropanolamine	2 g
Perfume, colour, preservatives	Q.S
Water	48 g

Evaluation of shampoo:

Performance and characteristics

1. Foam and foam stability
2. Detergency and cleaning action
   - Effect of water hardness
   - Surface tension and wetting
   - Surfactant content and analysis
3. Product Characteristics
   - Fragrance
   - Colour
   - Consistency
   - Package
4. Rinsing
5. Conditioning action
   - Softness
   - Lustre
   - Lubricity
   - Body texture and set retention
   - Irritation and toxicity
   - Dandruff control
6. Microbiological assay
7. EYE irritation test

1. Foam and foam stability:

The Ross-Miles foam column test is accepted. 200 ml of surfactant solution is dropped into a glass column containing 50ml of the same solution. The height of the foam generated is measured immediately and again after a specified time interval and is considered proportional to the volume. Barnett and Powers developed a lather meter to measure the effect of variables such as water hardness, type of soil and quantity of soil on foam speed, volume and stability.Fredell and Read titrated actual standard oiled heads of hair with additive increments of shampoo until a persistent lather end point appeared.

2. Detergency and cleaning action:

Cleansing power is evaluated by the method of Barnet and Powers 5gm sample of soiled human hair is placed at 35°c in 200 cc of water containing of 1 gm of shampoo. The flask is shaken 50 times a minute for 4 minutes. Then washed once again with sufficient amount of water, then after filter the hair dried and weighed. The amount of soil is removed under these condition is calculated.

3. Wetting Action:

Canvas disk sinking test: A mount Veron cotton duck # 6 canvas disk 1 inch in diameter, is floated on the surface of a solution, and the time required for it to sink is measured accurately.

4. Rinsing:

Skilled beauticians are employed to make comparisons on the performance of several shampoos.

5. Condi-tioning Action:

Conditioning action is a difficult property to assess. This is because it is basically dependent on subjective appraisal. No method has been published for measuring conditioning action. The degree of conditioning given to hair is ultimately judged by shampoo user who is making the evaluation on the basis ofpast experience and present expectations.

Microbiological assay:

Preparation of pre-inoculum: Take the loopful culture of staphylococcus aureus (ATCC6532) aseptically and transfer to sterilized and cooled 100 ml SCDM (broth).culture of Mix well. Incubate the broth at 37^{o}C for 24 hrs.

Preparation of media: Soya bean casein digests medium, soya bean casein digest agar and nutrient agar.

Preparation of pour plates sterilized: SCD agar (100 ml) is cooled to 40°C and mixed with 5 ml of 24 hrs old pre inoculated culture. This is immediately poured in plates (340 ml each) and allows to set.making the wells on agar plate sample: The wells are dig on agar plates with sterilised well digger aseptically. Take 100µml of each sample, add to well aseptically. Incubate the plates at 37^{0}C for 24 hrs to 48 hrs. Observe the effectiveness of sample on culture growing on the agar plate and we can see the effectiveness of sample in the form of zone of inhibition around each well containing different sample.

6. Evaluation of eye irritancy:

The test calls for dropping 0.1 ml of liquid shampoo in the conjunctiva sac of one eye of the rabbit, the other eye serving as control. In the case of the first three animals, the treated eye remains unwashed. Since washing the eye may or may not alleviate symptoms of injury. The six remaining animals are divided into two equal groups. In the first of these groups eyes instilled with the substances are washed with 20 ml of lukewarm water two seconds after treatment and in the second group after instillation. Readings are then

made at 24, 48 and 72 hr and again four and seven days after treatment. If the lesions have not cleared up in seven days the test material is considered as severe irritant.

7. Viscosity:

Viscosity of the liquid shampoo is determined using a Brookefieldviscometer100 mL of the shampoo is taken in a beaker and the spindle is dipped in it for about 5 min and then the reading is taken.(24)

Hair Conditioner

Conditioners are applied to the hair after shampooing and are designed to smooth the hair, improve gloss and lustre, as well as recondition chemically damaged hair, mechanically damaged hair, and weathered hair

Figure: 3 Marketed product of Hair Conditioner

Table: 2 Common ingredients used in formulation of conditioner

Ingredients	Example
Conditioning agent	Diamethicone
Glosser	Cyclopentasilixane,diamethicone
Antistatic agent	Polyquternium-10 and Gaur hydroxypropyl trimonium chloride
Lubricants	Fatty alcohol, panthenol
Moisturiser	Prunus Amygdalus Dulcis(sweet almond oil)
Sunscreen	Benzophenones-4and ethylhexylmethoxycinnamate,cinnamidopyltrimonium
Surfactants	Behentrimonium chloride, Cetrimoniumcloride
PH regulator	Citric acid

General method of preparation:

- Add 90% of the water and the CTAB to the main manufacturing vessel. Heat to 70-7500 C.
- Melt the acetyl alcohol in a jacketed side vessel. Heat to 70-750 C.
- When both phases are 70 - 750 C, add the oil phase to the water phase by homogenization to form an emulsion.
- When the emulsion has formed, commence cooling to 400C with paddle stirring only.
- Dissolve the preservative in a portion of a reserved water. Add to the main vessel with continuous mixing.
- Add colour to the main vessel. Continue to cool. Add perfume to the main vessel.
- Mix until homogenous product is obtained.
- Adjust pH with citric acid dissolved in water to pH3.0 5.0 cool to 3500 C

Formulation of hair conditioner:

Table 3: Formulation of Hair conditioner

Ingredients	%w/w
Cetyl trimethyl ammonium bromide	3
Ceto stearyl alcohol	2.50
Perfume, colour, preservative	Q.S
Citric acid	pH3.0-5.0
Water	Upto 100

Evaluation of conditioner:

1. Values of durability and adhesion.
2. Viscosity: Rhotic R3 Rotational viscometer are used.
3. Contact angle: Contact angle is measured on the Teflon surface by using Goniometer (G-10 Contact angle meter). Three successive drops are put on the Teflon plate. The angle between the base of the drop and the tangent at the edge of the drop is measured
4. Surface tension: Surface tension measurements are done using the Wilhelm/Du Nouy ring apparatus on Kruss K100 tensiometer.(25)

Mineral oil and vegetable oil

There are few articles published about the effect of mineral and vegetable oils on human hair. The main physical property of this class of ingredients is the hydrophobicity of the oil. Saturated and monosaturated oils diffuse into the hair much better than polyunsaturated oils.(26)

Oils play an important role in protecting hair from damage. Some oils can penetrate the hair and reduce the amount of water absorbed in the hair, leading to a lowering of swelling. (27)This can result in lower hygral fatigue (repeatedsweeling anddrying),a factor that can damage hair .the oil can fill the gap between the cuticle cells and prevent the penetration of the aggressive substances such as surfactants into the follicle. Applying oil on a regular basis can enhance lubrication of the shaft and help prevent hair breakage. Rele and Mohile in 2003, studied the properties of mineral oil, coconut oil and sunflower oil on hair.(28)Among three oils, coconut oil was the only oil found to reduce the protein loss for both undamaged and damaged hair when used as a prewash and post wash grooming product. Both sunflower and mineral oils do not help in reducing the protein loss from hair. This difference in results could arise from the composition of each of these oils. Coconut oil, being a triglyceride of lauric acid (principal fatty acid), has a high affinity for hair proteins and because of its low molecular weight and straight linear chain, is able to penetrate inside the hair shaft. Mineral oil, a hydrocarbon, does not penetrate. Sunflower oil is a triglyceride of linoleic acid with a bulky structure and double bonds and has limited penetration to the fiber, not reaching the cortex. The mineral oil and the sunflower oil may have a film effect and adsorb to the surface of the cuticle enhancing shine and diminishing friction and for these, avoid hair damage (29)

Keis et al. in 2005 studied the effect of coconut oil, olive oil, sunflower oil and mineral oil on the hath(30)Except for mineral oil, heat decreased the capillary adhesion of the other oils, resulting from the penetration into the hair

fiber by diffusion, leaving a thin film on the surface). Although thick films of oil can mask the lifted scales of the cuticle, it may leave an oily and heavy look to the hair. It is preferred to reapply oils that leave a thin layer on the surface and are well absorbed by the fiber. In 2009, the Brazilian oils and butters were studied by Fregonesi et al. They analyzed the following substances: Passion fruit seed (77% linoleic acid), Brazilian nut (38% oleic acid and 35% linoleic acid), palm olein (47% oleic acid), buriti (79% oleic acid), palm stearin (42% palmitic acid and 41% oleic acid), tucumã (48% lauric acid and 27% myristic acid), ucuúba (75% myristic acid), sapucainha (47% chaulmoogric acid, 27% hydnocarpic and 19 gorlic acid). Oil treatment reduced the combing force percentage for wet conditions. However, the hair treated with butters showed poor combing. Treatments using oils reduced the formation of split ends in the hair. Tresses treated with Brazilian nut and mineral oils gave the lowest formation of split ends.(30)

The reduction of combing forces is a combination of water wetting and the lubricant effects of the oil on the fibers. Butters increased the combing force. Butters in raw state are not as fluid as oils and do not spread easilyalong hair tresses. The Brazilian nut, passion fruit seed, palm olein, buriti and mineral oils produced combing force reduction. Mineral oil has no affinity to hair's proteins and is not able to diffuse in the fiber. Mineral oil main effects are its higher spreading capability on the hair surface which improves gloss, combing facility and reduces split end formation(31)

In 2007 Keis et al.(32)studied the effect of oil films on moisture vapor on human hair to analyze the capability of oils to reduce the moisture pick up. Although coconut oil penetrates, the fiber and mineral oil does not, there is the equivalent reduction on water sorption for both oils. Increasing the thickness of the oil layer on the fiber surface increased hair moisture regain. The oil that remains in the cuticle layer and not the oil that penetrates the cortex is the one responsible for the decrease in the water pick up.

Marrocan argan oil has become very popular as a hair cosmetic main ingredient, referred as capable of keeping the hair moisturized and hydrophobic. Morocco's argan oil is now the most expensive edible oil in the world. The argan tree (Argania spinosa L. Skeels), an endemic tree in Morocco, is the most remarkable species in North Africa, due to its botanical and bioecologic interest as well as its social value. The oil is rich in tocopherols and polyphenols, powerful antioxidants. (33)Argan oil is extracted from the kernels of argan fruits that have been sun-dried for either a few days or up to several weeks. The fruit drying time influences the quality of the extracted oil.(34)Although there is scientific literature about the use of the Moroccan oil for chronic conditions such as atherosclerosis and psoriasis for its cardioprotective properties, there is a lack of data about the benefits for hair care. (35,36).

Figure 4: Hair oil

Hair Dye:

Introduction: Hair dye use is very common among both the genders, today millions use it. Coloring of hair is performed not only by professionals but also a popular cosmetic procedure at home. Hair is made up of root and shaft. Shaft has three layers: Cuticle consisting of tightly packed colorless cells, cortex contains natural color pigments that determine color and medulla a hollow core. Hair dye cosmetic products are those cosmetic products used for coloring hair. These products were initially designed for women to hide grey hair, but they are increasingly being used by men and, in fact, nowadays various hair dye products exclusively designed for men can be found on the market. The reasons for using this type of product may be different now, not just to hide grey hair, but also to potentiate the natural hair color or to change it completely. In any case the main reasons behind all of these are fashion and feeling more attractive. Hair dye products are mainly classified into two main categories according to their duration in the hair, i.e., temporary and permanent, which in turn are subdivided into temporary and semi-permanent, and permanent and demi-permanent hair dye products, respectively. This classification is in line with the type of active ingredients involved in the dyeing process and with the dyeing process itself, known commonly as non-oxidative and oxidative hair dye products. The coloring ingredients used in each type of hair dye product and the dyeing process involved.

Figure 5: Different herb used in hair dye

1. **Amla**:

Amla (Emblica officinal is, Family- Euphorbiaceae) is deciduous tree widely found in India at the height of 350 m.It is often cultivated at commercial level in Uttar Pradesh, Gujarat, Rajasthan and Maharashtra. Amla contains 5-6% of tannins such as gallic acid, ellagic acid and phyllembelin. It is commercialized in the form of shampoos and hair oil. Mainly its oil and aqueous extract is used in the hair care formulations.

2. **Bhringraj**:

Bhringraj (Eclipta Alba Linn, Family- Asteraceae) is anannual or perennial plant found in moist places throughout India, ascending up to 600 fts. Bhringraj mainly contains coumestans, alkaloid, glycosides, triterpenic acid and steroids.

3. **Henna**:

Henna (Lawsonia inermis, Family- Lythraceae) grows wild and cultivated as garden plant throughout India. Henna leaves are the part of plant that is used in hair formulations. Leaves mainly contain lawsone (quinone) dissolve in basic pH to give dark intense orange color. Henna leaves have been used from ancient time as a hair color due to the chemical interaction of lawsone (thiol group) to the keratin.

4. **Reetha**:

Its fruit is rich in vitamin A, D, E, and K, saponin, sugars, fatty acids and mucilage. Reetha extract is useful for the promotion of hair growth and reduced dandruff. Extract of fruit coat acts as a natural shampoo, therefore, is used in herbal shampoos in the

form of hair cleanser. Reetha as soapnuts or washing nuts, play an important role as natural hair care products since older times. This plant isenriched with saponins, which makes the hair healthy, shiny, and lustrous when used on regular basis.

5. Shikakai:

It contains Lupeol, Spinasterol, Lactone, Hexacosanol, Spinasterone, Calyctomine, Racimase-A Oleanolic acid, Lupe none, Betulin, Betulinic acid. The extract obtained from its pods is used as a hair cleanser and for the controlof dandruff. Shikakai or acacia concinna, has rich amount of vitamin C, which is beneficial for hair. Shikakai naturally lowers the pH value and retains the natural oils of the hair and keeps them lustrous and healthy. It is also effective in strengthening and conditioning hair. Amla, reetha and Shikakai compliments each other, therefore, they are mixed together to have healthy and lustrous hair. All of these ingredients come in two forms, one as a dried fruit and other in powdered form. Amla, Reetha and Shikakai suit all hair types and help prevent split ends, hair fall, dandruff, greying of hair and other hair related problems, to make hair soft and silky.

6. Coffee:

In hair colorants, herbs can be used in the form of powder, aqueous extract or their seed oil to impart shades of differentcolor varying from reddish brown to blackish brown. The herbal drugs like coffee powder obtained from its seeds are used as hair colorants.

7. Tea

Being rich in polyphenols, selenium, copper, phytoestrogens, melatonin, tea also has been used intraditional Chinese medicine and in Ayurvedic medicine has been used since long as hair colorant.

8. Hibiscus:

It is excellent for increase in hair growth activity. Hibiscus is naturally enriched with Calcium, Phosphorus, Iron, Vitamin B1, Vitamin C¸ Riboflavin and Niacin, which help to promote thicker hair growth and decreases premature graying of hair. This flower is used for controlling dandruff. Hibiscus exhibits antioxidant properties by producing flavonoids such as anthocyanins and other phenolic compounds. It can be used to rejuvenate the hair by conditioning it. :

How to made Hair Dye:

Preparations such as these were the only hair dyes available until the late nineteenth century. Hydrogen peroxide was discovered in 1818, but it was not until 1867 that it was exhibited at the Paris Exposition as an effective hair lightener. A London chemist and a Parisian hairdresser began marketing a 3% hydrogen peroxide formula at the Exposition as golden fountain of youth water and this was the first modern chemical hair colorant.

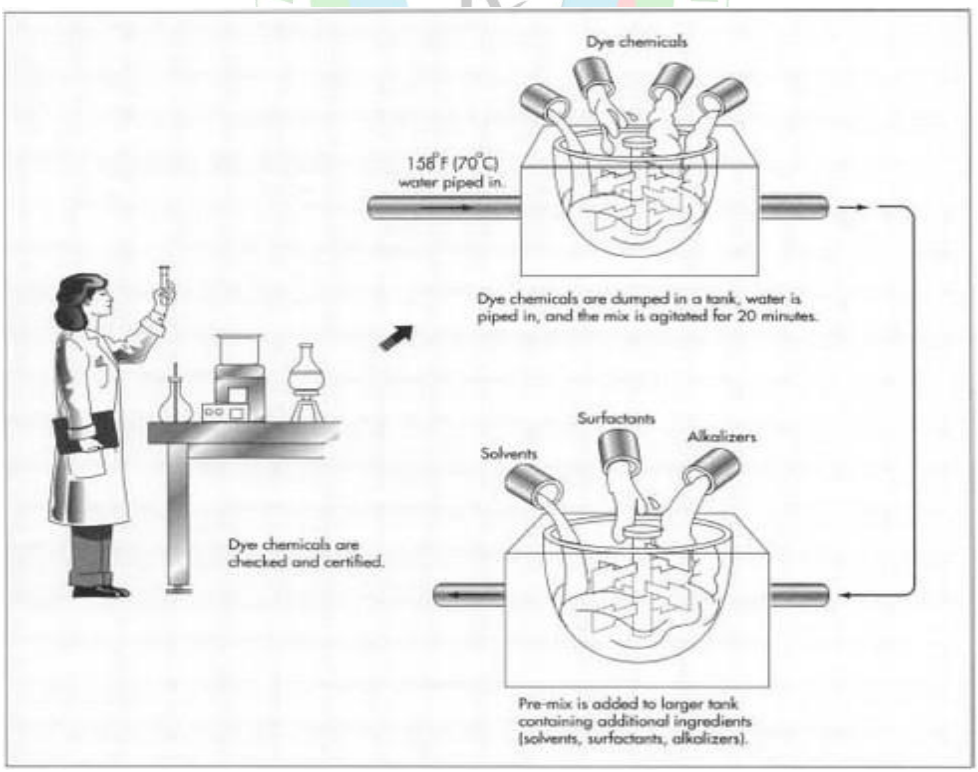

Figure: 6 How to made Hair Dye

Advances in chemistry led to the production of more hair dyes in the late nineteenth century. The first synthetic organic hair dye developed was pyrogallol, a substance that occurs naturally in walnut shells. Beginning in 1845, pyrogallol was used to dye hair brown, and it was often used in combination with henna.,So-called amino dyes.were developed and marketed in Europe in the 1880s. The earliest was p-phenylenediamine, patented in

Germany by E. Erdmann in 1888 as a dye for fur, hair, and feathers. To dye hair with p-phenylenediamine and related dyes, a weak solution of the chemical, mixed with caustic soda, sodium carbonate, or ammonia, was applied to the hair. Then hydrogen peroxide was applied, which brought out the color. The amino dyes produced a more natural-looking black than previous dyes, and could make shades of red and brown as well

Raw material:

Most commercial hair dye formulas are complex, with dozens of ingredients, and the formulas differ considerably from manufacturer to manufacturer. In general, hair dyes include dyes, modifiers, antioxidants, alkalizers, soaps, ammonia, wetting agents, fragrance, and a variety of other chemicals used in small amounts that impart special qualities to hair (such as softening the texture) or give a desired action to the dye (such as making it more or less permanent). The dye chemicals are usually amino compounds and show up on hair dye ingredient lists with such names as 4-amino-2-hydroxytoluene and m-Aminophenol. Metal oxides, such as titanium dioxide and iron oxide, are often used as pigments as well. Other chemicals used in hair dyes act as modifiers, which stabilize the dye pigments or otherwise act to modify the shade. The modifiers may bring out color tones, such as green or purple, which complement the dye pigment. One commonly used modifier is resorcinol, though there are many others. Antioxidants protect the dye from oxidizing with air. Most commonly used is sodium sulfite. Alkalizers are added to change the pH of the dye formula, because the dyes work best in a highly alkaline composition. Ammonium hydroxide is a common alkalizer. Beyond these basic chemicals, many different chemicals are used to impart special qualities to a manufacturer's formula. They may be shampoos, fragrances, chemicals that make the formula creamy, foamy, or thick, or contribute to the overall action of the formula. Hair dyes are usually packaged with a developer, which is in a separate bottle. The developer is most often based on hydrogen peroxide, with the addition of small amounts of other chemicals depending on the manufacturer.

Manufacturing process:

Checking ingredients: Before a batch of hair dye is made, the ingredients must be certified. That is, the chemicals must be tested to make sure they are what they are labeled, and that they are the proper potency. Certification may be done by the manufacturer in-house. In many cases, the ingredients arrive from a reputable distributor who has provided a Certificate of Analysis, and this satisfies the manufacturer’s requirements.

Weighing:

Next a worker weighs out the ingredients for the batch. For some ingredients, only a small amount is necessary in the batch. But if a very large batch is being made, and several ingredients are needed in large amounts, these may be piped in from storage tanks.

Pre-mixing:

In some hair dye formulas, the dye chemicals are pre-mixed in hot water. The dye chemicals are dumped in a tank, and water which has been already heated to 158°F (70°C) is pumped in. Other ingredients or solvents may also be added to the pre-mix. The pre-mix is agitated for approximately 20 minutes.

Mixing:

The pre-mix is then added to a larger tank, containing the other ingredients of the hair dye. In a small batch, the tanks used may hold about 1,600 lbs (725 kg), and they are portable. A worker wheels the pre-mix tank to the second mix tank and pours the ingredients in. For a very large batch, the tanks may hold 10 times as much as the portable tanks, and in this case they are connected by pipes. In a formula in which no pre-mixing is required, after checking and weighing, the in gredients go directly tothe mixing step. The ingredients are simply mixed in the tank until the proper consistency is reached. If a heated pre-mix is used, the second mix solution must be allowed to cool. The ingredients that follow the pre-mix may be additional solvents, surfactants, and alkalizers. If the formula includes alcohol, it is no added until the mix reaches 104°F (40°C), so that it does not evaporate. Fragrances too are often added at the end of the mix.

Filling:

The finished batch of hair dye is then piped or delivered to a tank in the filling area. A nozzle from this tank lets a measured amount of hair dye into bottles, moving beneath it on a belt. The filled bottles continue the belt to machines, which affix labels and cap them.

Packaging:

From the filling area, the bottles are taken to the packaging line. At the packaging line, the hair dye bottle is put in a box, together with any other elements such as a bottle of developer or special finishing shampoo, instruction sheet, and gloves and cap, or any other tools provided for the consumer. After the package is complete, it is put in a shipping carton. The full cartons are then taken to the warehouse to await distribution.

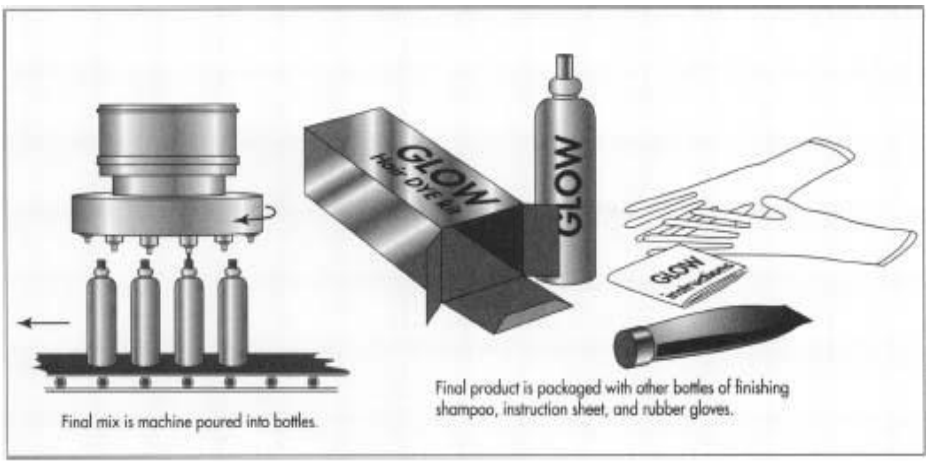

Figure 7: Manufacturing process of Hair Dye

Mechanism of Hair Dying:

Human Hair is a protein fiber made of two layers. The inner layer called cortex contains melanin. Melanin is a pigment which gives your hair shades of blonde, black, auburn or brown. Cortex is covered by another layer called cuticle. Cuticle provides protection to cortex and luster to your hair. Cuticle is inert in nature so it cannot biologically or chemically absorb any color.

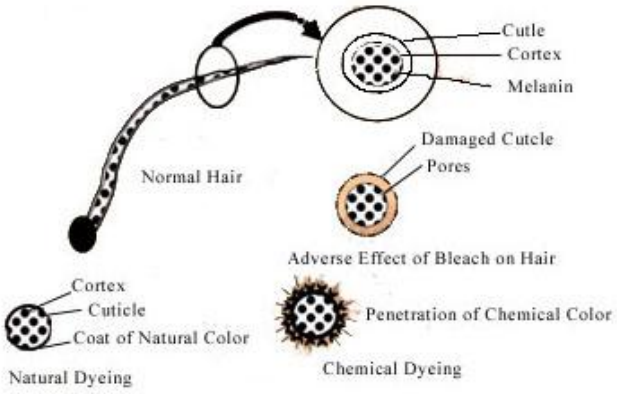

Figure 8: Mechanism of Hair Dying

Mechanism of Hair Dying:

By Chemical Dye: Most of the chemical dyes contain bleaching agents such as ammonia and/or peroxide which damage the outer most layer and create capillaries in hair shaft. Then PPD, OPD, MPD like chemical color fills these capillaries, enter in the inner layer and remain stuck inside, as permanent color. The next application again does the same on hair shaft. This results in loss of strength, roughness and permanent damage to hair.

By Natural Dye:

Natural Dye colors hair by coating the hair shaft. It provides thickness to hair and stick as a semi-permanent color. The next application again does the same and results in increase in strength and shine in hair.

Side effect of using hair dye

Overexposure

Permanent hair dyes contain ammonia and peroxide. Peroxide strips away the natural color of hair and thus exposing your hair to these chemicals regularly can cause your hair to lose luster, break easily and even lead to eventual hair fall.

Allergic reactions

Dyes contain paraphenyldiamine which is an allergen. By this, people who have dermatitis can have a severe reaction. People with eczema and psoriasis should avoid hair dyes. Not only this, but can also cause itching, skin irritation, redness, and swelling.

Effect on Pregnancy

Coloring hair can prove to be fatal for the unborn infant of pregnant women as it may cause malignancy.

Asthma

Hair dyes contain persulfates which can aggravate asthma. Continuous inhalation of the chemicals can cause coughing, lung inflammation and even asthma attacks.

Safety of hair dye

Epidemiologically and human monitoring studies have not detected any risk of carcinogenity of the ingredients used nowadays. Contact dermatitis is the main reaction. Turati. Meta-analysis definitively excluded any appreciable excess risk of bladder cancer among personal hair dye users. Although paraphenylenediamine is a

common allergen, resorcinol and m-aminophenol were found more frequently in the work of Hamann although many studies have tried to find some linkage between hair dyes ingredients and cancer hazard, there is no conclusive study confirming this hypothesis.

Hair Dye Safety Checklist:

- Follow all directions on the label and in the package.
- Do a patch test on your skin every time before dyeing your hair.
- Keep hair dyes away from your eyes, and do not dye your eyebrows or eyelashes. This can hurt your eyes and may even cause blindness.
- Wear gloves when applying hair dye.
- Do not leave the product on longer than the directions say you should. Keep track of time using a clock or a timer.
- Rinse your scalp well with water after using hair dye.
- Keep hair dyes out of the reach of children.
- Do not scratch or brush your scalp three days before using hair dyes.
- Do not dye or relax your hair if your scalp is irritated, sunburned, or damaged.
- Wait at least 14 days after bleaching, relaxing, or perming your hair before using dye.
- Read the ingredient statement to make certain that ingredients that may have caused a problem for you in the past, such as p-phenylenediamine (PPD) are not present.
- If you have a problem, tell your healthcare provider.

Follow these safety tips when dyeing your hair:

- Don't leave the dye on your head any longer than needed.
- Rinse your scalp thoroughly with water after using a hair dye.
- Wear gloves when applying hair color.
- Carefully follow the directions in the hair dye package.
- Never mix different hair dye products.
- Be sure to do a patch test for allergic reactions before applying the dye to your hair. Almost all hair dye products include instructions for doing a patch test. It's important to do this test each time you dye your hair. Make sure your hairdresser also does the patch test before dyeing your hair. To test, put a dab of dye behind your ear and don'twash it off for two days. If you don't have any signs of allergic reaction, such as itching, burning, or redness at the test spot, you can be somewhat sure that you won't have a reaction to the dye when it's applied to your hair. If you do react to the patch test, do the same test with different brands or colors until you find one to which you're not allergic.
- Never dye your eyebrows or eyelashes. The FDA bans the use of hair dyes for eyelash and eyebrow tinting or dyeing even in beauty salons. An allergic reaction to dye could cause swelling or increase risk of infection around or in your eyes. This can harm your eyes and even cause blindness. Spilling dye into the eye by accident could also cause permanent damage.(37)

Silicone

Silicone is a polymer that contains silicon and oxygen atoms. The main chain is Si-O and attached methyl groups. The structure is shown in Figure

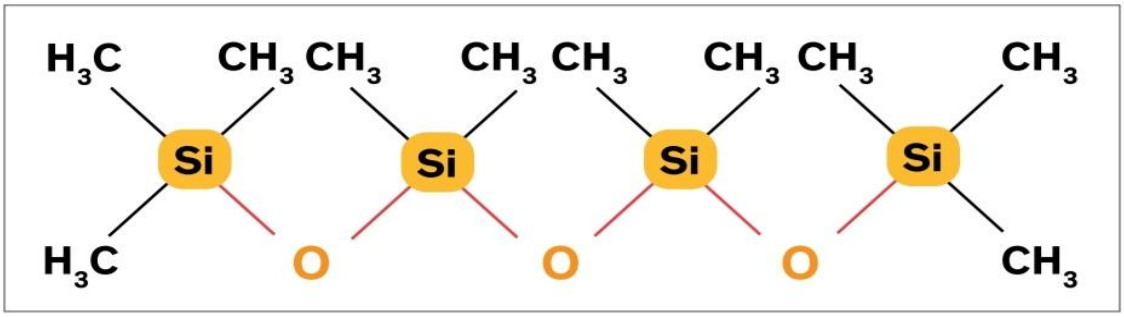

Figure 9: Polydimethysiloxane (Dimethicone) structure

The variations on the structure to the right are almost endless, making silicone chemistry almost as broad as carbon chemistry. The following modifications can be made: molecular weight variations or adding organic functionalities, such as polyether, alkyl, amino, resulting in a range of materials, from volatile fluids to gums, waxes, and elastomers. The polymer can be oil or water soluble. Silicones are a very broad chemical family and not a single material.The Si-O bond is very stable, not easily oxidized, and therefore inert, an advantage when in contact with biological tissues. The bond length of Si-O is 0.163 nm, and its angle is 130°, larger than the bond length of C-C (0.154 nm) and bond angle (112°), allowing oxygen and water vapor to permeate and therefore not interact with skin breathability.There is also no evidence on negative impact to the scalp.

This is demonstrated by extensive silicone use in wound care products, as it can avoid skin maceration. Indirectly related to permeability, several silicones among which are dimethicone, silicone, wax, silicone polyether, and cyclomethicone, are shown to be noncomedogenic. Their low surface tension makes silicone spread very well and also confers hydrophobicity. As a consequence of these physical and chemical properties, polydimethylsiloxanes (dimethicones) from 350 – 12,500 cSt are listed in the

FDA Monograph: "Skin Protectant Drug Products for Over-the Counter Human Use; Diaper Rash Products," issued in 1990. The level needed for a protectionclaim is as low as 1%. As early as 1953, silicone was used in hand cream to provide protection.

Silicone History in Hair Care

Silicones have been widely used in a range of hair care products since the 1970s. For example, silicones were used in hair sprays for plasticizing styling resins, and in 1975, "Toni" Gilette, a home permanent containing amodimethicone, was launched.In the mid-1980s, a totally new application, hair serums, was launched. These materials mainly contain silicone gum dispersed in volatile silicones and were positioned to mend hair split ends. They also acted as conditioner for shine, easy combing and smoothness. These products still exist today.

At the end of the 1990s, amino silicones made their entrance in the hair colors segment, providing protection against color fade and maintenance of color depth and gloss when added to the colorant formulation itself, but also from shampoos and conditioners in addition to their well-known conditioning performance.

Safe used of silicone in hair care product:

Silicones are also typically used in antidandruff shampoos as part of scalp care, where they help to counteract the negative impact of anti-dandruff active on conditioning

Additional information on the interaction of silicones with the hair and scalp can be found on hair care products manufacturer website highlighting the conditioning benefits of silicones and giving recommendations on which shampoo to select for specific hair needs, with silicone containing shampoos and conditioners recommended for damaged hair.

Silicone Benefits in Hair

Care Products

Silicones are recognized as multifunctional ingredients in a variety of hair care products. With their unique set of chemical and physical properties, these highly versatile materials not only condition hair, but they can be used to add shine, make combing easier, provide color protection, help guard against damage from heat styling, enhance hair strength, repair damaged hair, give a perception of moisturization, aid curl retention, control frizz and add volume—or even reduce volume. In short, silicones can play major roles—whether in shampoos, conditioners, colorants or styling products.

Color protection:

Silicones can help colored hair last longer, retain its vibrant look, and protect and enhance color and shine. Rinse-off conditioners containing different types of silicones have shown increase in color retention for hair that has been colored.

Heat Protection

Protecting hair from excessive heat is clearly a need among many consumers. Hair dryers and other heated appliances first soften the keratin of the hair. If the appliances are too hot, they can actually cause water in the hair to boil, forming minute bubbles of steam inside the softened hair shaft, weakening the fiber and potentially leading to total fracture. Silicones are thermally stable and spread easily on the hair, forming a protective film to help prevent water loss from the hair shaft caused by the heat of dryers or heated styling tools.

Hair Strengthening

Heat, styling and color treatments are not the only causes of hair damage. Even common grooming habits like washing, towel drying and brushing can cause hair breakage. Silicones were evaluated for hair strengthening benefits using single fiber tensile measurements. Fiber treated with silicones exhibited higher load resistance compared to untreated fiber, demonstrating hair strengthening benefits in leave-in applications.(38)

Figure 10: Silicon containing Marketed Product.

Hair gel

Gels are semisolid system in which a liquid phase is constrained within a three dimensional polymeric matrix (consisting of natural or synthetic gum) in which a high degree of physical or chemical cross linking has been introduced. Gels are relatively newer class of dosage form created by entrapment of larger amount of aqueous hydro alcoholic liquids in a network of colloidal solid particles which may consist of inorganic substance such as aluminum salts or organic polymers of natural or synthetic origins(39)

Flaxseed (also known as linseed) is emerging as an important functional food ingredient because of its rich contents of a-linolenic acid (ALA, omega-3 fatty acid), lignans, and fiber[1]. Flaxseed oil, fibers and flax lignans have potential health benefits such as in reduction of cardiovascular disease, atherosclerosis, diabetes, cancer, arthritis, osteoporosis, autoimmune and neurological disorders[2]. Apart from this, flaxseed is full of fatty-acids and anti-oxidants which help to remove toxins and dead cells from the scalp. Flax seed gel can be applied to scalp and hair as a moisturizer that can help to stimulate growth and improve the strength of existing hair. Topical formulations include oils, creams, ointments, pastes and gels out of which gels are getting more popular now a days because they are more stable and also can provide controlled release than other semisolid preparations. The gel formulations can provide better absorption characteristics and hence the bioavailability of drug(40)Gels are the transparent clear dosage form in which drug can be interrupted in aqueous form.The gels are form cross linking structure relatively newer class of dosage forms created by entrapment of large amounts of aqueous or hydro-alcoholic liquid in a network of colloidal solidparticles. topical gels are prepared with polymers such as Carbomers which impart anaesthetically pleasing, clear sparkling appearance to the product and a easily washed off the skin withwater.(41)

METHODOLOGY

Formulation of hair gel base

Weighed quantity of polyethylene glycol and measured quantity of glycerin, methyl paraben, were dissolved in 35 ml of water in a 250 ml beaker. Then the mixture was stirred using mechanical stirrer at high speed. Suitable quantity of carbopol 934 and PVP were added slowly to the beaker containing above mixture of liquid with continuous stirring. Then triethnolamine (gelling agent) was added slowly with continuous stirring until gel structure was obtained. In order to optimize the concentration of carbopol, five various gels containing varying concentrations of carbopol such as 0.5g, 1g, 1.5g, 2g and 2.5g (F1 to F5 respectively) were prepared. The gels formed using 0.5g and 1g carbopol 934 were found to be very thin that liquefied within 4 to 5 hours of preparation. With 1.5g carbopol 934 the gel formation was better to some extent but the problem of liquefaction after 24 hours was observed. The gel formulation containing 2g of carbopol 934 formed uniform and smooth gel that did not liquefy even after 24 hrs. Whereas gel containing 2.5g carbopol was too thick to be handled. Among the Five formulations, gel containing 2g carbopol 934 (F4) .

Preparation of herbal hair gel

The aqueous extract of flaxseed was prepared by adding flaxseeds to boiling water with constant stirring until a thick mucilage wasobtained. Then the mucilage was strainedusing suitable sieve and stored at room temperature until further use®. Five different herbal hair gel formulations were prepared by simple gel preparation method with carbopol gel base. Measured quantity of methyl paraben, glycerin and weighed quantity of polyethylene glycol were dissolved in about 35 ml water in a beaker. Then the mixture was stirred at high speed using mechanical stirrer. 2g carbopol 934 (optimized) and PVP were added slowly to the beaker containing above liquid while stirring. Then triethanolamine was added slowly with continuous stirring to obtain gel structure. Finally varying concentrations of aqueous extract of flaxseed (5%, 10%, 15%, 20% and 25%) was incorporated into carbopol gel and stirred for about 1 hour so as to obtain H1F4, H2F4, H3F4, H4F4 and H5F4 containing 5%, 10%, 15%, 20% and 25% flaxseed extract in F4 carbopol gel formulation . The prepared herbal gel formulations were stored at room temperature until further evaluation.

Figure 11: Marketed product of Hair Gel

Evaluation:

Physical appearance

The gel formulation was evaluated in terms of physical character like phases separation and change incolor, odour and rheological parameters.

Homogeneity

Developed gel was tested for homogeneity by visual inspection after the gel was set in the container. Itwas tested for appearance, presence of any aggregates and flocculates.

pH

The pH of the gel formulation was determined by using digital pH meter. One gram of gel was takenand dissolved in 100 ml distilled water and measurement of pH was done in triplicate and average value was calculated.

Washability

The prepared hair gel formulation is applied on the skin and then eases and extent of washing with wateris checked normally.

Extrudability

The prepared hair gel formulation is filled intocollapsible tubes. The tube is pressed to extrude thematerial and the Extrudability of the formulation was checked.

Spreadability

The weighed quantity of gel (2g) was sandwiched between two glass slides. 500g of weight was placed on the slides. The weight was placed for specific period of time for 5 minutes. Then weight was removed and diameter of the spread circle was measured at different points. Spreadability was calculated by using formula.

- S=M.L/T
- Where. S= Spreadability.
- M= Weight placed on the slide. L-diameter of circle in cm, T-time in seconds.

Skin irritation test

Applied the herbal hair gel formulation on the skin and observe for irritation, redness or rashes.

Anti-fungal activity

The inhibition of fungal growth under standardizedconditions may be utilized for demonstrating the therapeutic efficacy of antifungal drugs. The microbiological evaluation of gels was done using cup-plate method, which depends upon diffusion of the drug from the gel contained in the cup through a solidified agar layer in the Petri dish to an extent such growth of the added microorganism is prevented entirely in a zone around the cup. Wider zone of inhibition is an indicative of better release of the drug from the base.

Stability study:

Stability of a drug has been defined as the ability of a particular formulation. In a specific container, to remain within its physical, chemical, therapeutic and toxicological specifications. The purpose of stability testing is to provide evidence on how the quality of a drug substance or drug product varies with time under the influence of a variety of environmental factors such as humidity and light, and enables recommended storage conditions, re-test periods and shelf lives to be established. In the present work the formulation was stored at room temperature (25-30°c) for 30 days and observed for any changes in their physical characteristics and evaluation parameters (39)

CONCLUSION:

The review concludes that effective hair-care formulations must balance cleansing, conditioning, protection, and therapeutic properties. While synthetic surfactants and chemical dyes remain widely used, they may cause long-term hair and scalp damage. Herbal alternatives such as Amla, Bhringraj, Henna, Reetha, Shikakai, Hibiscus, and flaxseed present safer and multifunctional benefits, including hair growth promotion, dandruff control, natural coloring, and protection against damage. Incorporation of oils such as coconut and argan further enhances hair strength and reduces protein loss. The use of silicones adds value by improving shine, smoothness, and heat protection. Evaluation methods including foam tests, conditioning assessments, antifungal activity, and stability studies ensure product safety and efficacy. Therefore, combining traditional herbal knowledge with modern formulation techniques can lead to the development of effective and sustainable hair-care products.

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